INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 13, No. 2, p. 225-236, 2018
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Impacts of anthropogenic activities on alien plant invasion in MT. Manunggal, Cebu Island, Philippines

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Article published on August 30, 2018

Key words: Anthropogenic activities, Invasive alien plants (IAPs), Mt. Manunggal.

Abstract

A growing problem for the vast extents of diverse tropical forests in the Philippines is degraded every year due to booming population and introduction of invasive alien plants (IAPs). This study aimed to (1) assess the impacts of anthropogenic activities on the propagation of IAPs; (2) identify the resident's purpose of utilizing IAPs; (3) identify the least and most invasive life forms in response to anthropogenic activities that are present in highly disturbed (S1) and less disturbed sites (S2) of Mt. Manunggal, Cebu Island, Philippines. Both sites were sampled by establishing four quadrats per transect and tallying each plant per quadrat to identify its total abundance per species last October-November, 2016. Residents were also interviewed to identify how IAPs were utilized and to show the relationship of anthropogenic activities and IAPs in S1 and S2. Linear regression analysis revealed that as anthropogenic activities increased, high patronization of the IAPs were also observed in Mt. Manunggal, Cebu Island, Philippines. High IAP consumption was enough to address the immediate needs of the residents, which in turn exacerbate the spread and establishment of IAPs in both sites. At present levels, grasses and herbs were seen to be the most invasive life forms with largest impact in S1 and S2. The direct relationship between anthropogenic activities and IAPs could result in a dramatic rise of alien plants, and may intensify risks of impacts on native plants and its ecosystem.

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Introduction

Though the impacts of invasive alien species (IAS) on native species diversity are globally documented in the last decade, emergent evidence has accumulated in which these IAS impact ecosystems leading to biotic homogenization. In particular, impact ranges from individual through population, community and species which affect ecosystem structure and dynamics (Pysek and Richardson, 2006; Fitzpatrick and Hargrave, 2009; Pysek *et al.,* 2011; Pysek *et al.,* 2012). When introduced in a new range of environmental condition, IAPs have the tendency to proliferate due to its liberation from native predators which eventually affect the biotic-abiotic components and dynamics of an environment (Xu *et al.,* 2006; Pysek *et al.,* 2012). Generally indicated as the second prominent cause of species endangerment and extinction, continuous increase of IAPs gradually result in declining floral diversity and eventually allow successful establishment in novel ecosystems. In the Philippines, around 475 IAPs were identified since the antediluvian times (Sinohin, 2002).

The introduction of the first IAPs could be traced back on the Malayan-Polynesian origin where some of these species are considered to be an important source of agricultural and economic crops (Sinohin, 2002; Baguinon *et al.,* 2003). Moreover, majority of the IAPs were introduced during the Spanish government via Acapulco and galleon trade.

The additional IAPs were introduced after the Hispanic-American war and still the establishment of these IAPS continue to persist in the Philippines due to trade and later became tantamount with reforestation (Baguinon *et al.,* 2003).

The number of IAPs in the Philippines is increasing due to intentional or unintentional introduction, as well as the inadequate knowledge of many individuals on the ecological and environmental impacts of IAPs. Inhabitants continue to exploit the forest due to its valuable resources (i.e. wood for shelter and cooking, grasses for roofing and feed for livestock, edible fruits for food and economic purposes). Moreover, many Filipinos intentionally introduced IAPs for consumption (i.e. source for pasture, feeding stuff, ornamental plants, textile plants, medicinal plants, vegetables and fruits) and sold to local residents (Xu *et al.,* 2006; Bais *et al. 2008*). Continuous patronization of the villagers and negligence to their conduct to some of their activities may result to the establishment-proliferative mechanism IAPs. In particular, Mt. Manunggal of the Cebu province have documented IAPs which continue to increase exponentially (DENR-PAWB, 2014). Floral diversity of Mt. Manunggal is threatened by numerous factors associated to human-mediated activities, including alien species as primary driver of possible biotic homogenization and extinction. No baseline data or database, as well as the impacts of anthropogenic activities of all IAPs in Cebu was conducted, making this study emerge to be a logical next step.

The aims of this present study were to (1) assess the effects of anthropogenic activities on the propagation of IAPs; (2) recognize the resident's purpose of utilizing IAPs; (3) identify the least and most invasive life forms found in Mt. Manunggal, Cebu Island, Philippines. These are essential in understanding how anthropogenic activities promote invasion and diversity disruption in a well-protected area and what could be the negative effects of IAPs on the forested sites of Mt. Manunggal, Cebu Island, Philippines.

Materials and methods

Study area and selection of study sites

Mt. Manunggal is the highest mountain peak in Barangay Sunog, Balamban, Cebu and rises 1003 m above sea level, approximately 22 miles northwest of Cebu City. It has a total land area of 500 hectares with a latitude of 10° 27' 39.41" 1N and a longitude of 123° 46' 50.72" E. Its climate falls under Class IV, characterized by the occurrence of rainfall which is more or less evenly distributed throughout the year (PAGASA, 2016). Coolest temperature reaches as low as 19˚C, hottest months occur during March, while extreme temperature of 32˚C on April and May.

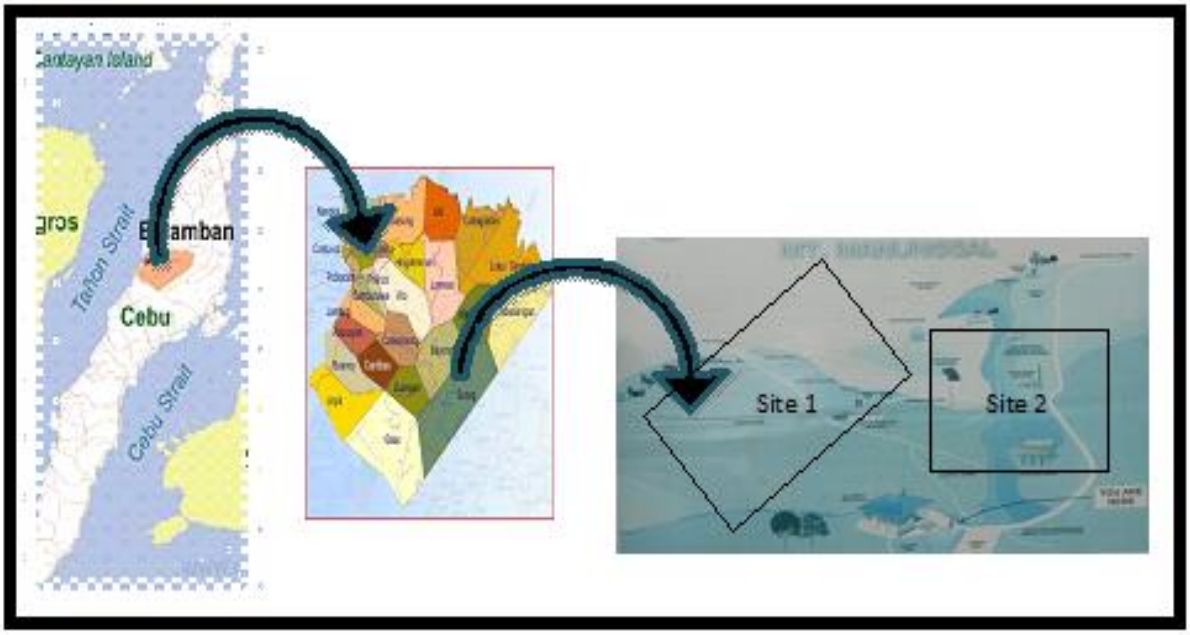

Fig. 1. The study site: Mt. Manunggal, Cebu Island, Philippines.

Coldest temperature is observed during the months of October-December. Fog usually covers the mountain range and ridges before sunrise and after sunset. The peak has been the object of visits by various sectors of some foreign and local tourists and their continuous influx, especially the migration from the lowlands, and the lack of environmental concern cause the rapid deforestation of the area and generally aggravates the depletion of the environment (DENR-VII, 1994). Moreover, the peak also has a secondary pocket forest, canyons, cliffs, caves, falls, gullies and creek that lead the water to drain to two main rivers, Combado River in Balamban which borders the Cebu Central Park in the north and Banban River which traverses the south portion of the park. The area is known to be a habitat of the endangered species like *Copsychus cebuensis*- black shama or locally known as 'siloy' and *Dicaeum quadricolor*- flower pecker ('panagoto'). Red 'lawaan' and 'kaningag' are known to be some of the rarest plant inhabitants growing in the forest.

Biological component

The researchers used a Descriptive Survey (i.e. total count or census of the species of plant population) as well as Transect-Quadrat Method (TQM) to determine the floral species as adapted from Wikum and Shanholtzer (1978) with modification. Site characterization was determined in the whole forest based on the degree and intensity of anthropogenic activities. Site 1 (highly disturbed) was characterized based on the observed prevalence of anthropogenic activities (i.e. urbanization, habitat fragmentation, grazing fields for livestock, pollution and encroachments). A large percentage of the land has been seen to be infested by IAPs in Site 1. For Site 2 (less disturbed), less anthropogenic activities were observed than in Site 1 where its land is inhabited by some native plants. A 100m x 50m area was established in each study site, where three (3) 100m-transect lines for each study site and were positioned with a distance of 10m from each other. Four 20m x 20m quadrats in each transect were laid out alternately from left or right with a 20m interval to randomly cover each study site. A total of 24 quadrats from the six (6) transects of the two study sites were randomly selected for sampling. Two sampling sites (Site 1- highly disturbed site and Site 2- slightly disturbed site) with an area of 18,000 m^2 were identified as research environment where these sites are anthropologically-disturbed and less-disturbed by human, respectively.

Socio-economic component

Prior to the conduct of interview, a permit from the barangay captain and mayor of Balamban, Cebu Island, Philippines was obtained. A gratuitous permit was also secured from DENR Region 7 to allow the researcher to assess the study site. A free, prior-informed consent was also asked from the residents. Consensus sampling was employed where all resident was interviewed in S1 and S2 of the study site. Information was gathered through a face-to-face interview using a semi-structured questionnaire to know the following: (a) demographic background of the residents, (b) native and alien plant species utilized, (c) possible cause of its entry to the site (e.g. anthropogenic activities), (c) utilization of IAPs in relation to their occupation, (d) the part of the plants that is beneficial to them, and (e) the life forms which are most commonly serves as their main source of supply and profit.

Data analysis

Total species abundance of all the IAPs and native plants was identified in both sites by counting the number of individuals per plant species. Linear regression analysis was employed to assess the relationship between anthropogenic activities (predictors) and IAPs (response variables). Descriptive statistics was also employed in all the data generated during the interview and were then recorded in excel. For statistical analyses, the data were subjected to Minitab Version 17.

Results and discussion

In the analysis of data, it revealed that Natural Habitat Loss, Habitat Fragmentation, Economic Purposes, Overgrazing and Urbanization are known factors which impact invasion of IAPs in both sites (β_4=103.7, t=12.9, p= 0.000, β_2=47.2, t=2.46, p= 0.020, β_6=39.4, t=2.18, p= 0.037, β_1=32.8, t=15.8, p= 0.046, and β_5=55.0, t=2.07, p= 0.047, respectively) (Table 1). That is, for every unit increase on the extent of Natural Habitat Loss, Habitat Fragmentation, Economic Purposes, Overgrazing, and Urbanization, a rise by 103.7 units, 47.2 units, 39.4 units, 32.8 units, and 55.0 units, respectively. Encroachment did not significantly predict the invasion and growth in the population of IAP (β_3=12.0, t=0.67, p= 0.507). This means that the greater the extent of the significant predictors (i.e. the significant identified factors affecting the proliferation of IAPs), the more successful IAPs are in establishing and proliferating in Mt. Manunggal.

Table 1. Effects of anthropogenic activities on the propagation of invasive alien plants (IAPs) in Mt. Manunggal, Cebu Island, Philippines.

Analysis of Variance (ANOVA)					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	48866076	8144346	15.48	0.000
Overgrazing	1	2262353	2262353	4.30	0.046
Habitat Fragmentation	1	3183978	3183978	6.05	0.020
Encroachment	1	236573	236573	0.45	0.507
Natural Habitat loss	1	34124059	34124059	64.87	0.000
Urbanization	1	2249505	2249505	4.28	0.047
Economic purposes	1	2499214	2499214	4.75	0.037
Error	31	16306480	526015		
Total	37	65172556			
Model Summary					
S		R-sq		R-sq(adj)	
725.269		74.98%		70.14%	

Legend: p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05

Habitat fragmentation (t=2.46; p=0.020; VIF=1.05) and Overgrazing (t=2.07; p=0.046; VIF=1.38) affect the cumulative increase of IAPs in Mt. Manunggal (Table 2). This is also in congruence in other tropical forests worldwide (Chown *et al.,* 2012; Pysek *et al.,* 2012). Overgrazing facilitates invasion indirectly by forming habitat fragments which leads to vegetation and ecosystem disruptions (Francl and Schnell, 2002) and thus provide high opportunities for IAPs to proliferate (Baider and Florens, 2011; García-Llorente *et al.,* 2011; Fried *et al.,* 2014). Farmers lengthening a tether allows easy collection of grasses and herbs to let animals graze for themselves. Once farmers pick an IAP with seeds, this increases the chance of easy transport through animals grazing (Qiang *et al.,* 2000).

Table 2. Effects of Anthropogenic Activities on the Propogation of IAPs in Mt. Manunggal, Cebu Island, Philippines.

Coefficients					
Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-1503	864	-1.74	0.092	
Overgrazing	32.8	15.8	2.07	0.046	1.38
Habitat Fragmentation	47.2	19.2	2.46	0.020	1.05
Encroachment	12.0	17.9	0.67	0.507	1.28
Natural Habitat loss	103.7	12.9	8.05	0.000	1.30
Urbanization	55.0	26.6	2.07	0.047	1.19
Economic purposes	39.4	18.1	2.18	0.037	1.19
Regression Equation Model:					
No. of Species = -211+ 75.2 Sold to people+ 91.5 Consumption+ 86.2 Feeds to livestock + 63.3 Human induced farming - 30.3 Medicinal purposes - 14.6 Prevent soil erosion					

Legend**:** p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05.

Disturbed and undisturbed sites provide an opportunity for the IAPs to proliferate and establish caused by the natural process of dislodgment of undigested material by the animal (Liu *et al.,* 1985; Zhao *et al.,* 1989). Other possible mode of invasion by IAPs include livestock where animals disperse fruits and seeds from while critters graze and becomes attached on animal's fur or wool (Kirichenko *et al.,* 2013). These spores and seeds could fall off its fur through wind or by mechanical ends such as scratching by the animal or lying of the animal unto the ground and eventually allow successful establishment of IAPs (Frenot *et al.,* 2005; Hughes *et al.,* 2010; Chwedorzewska *et al.,* 2011; Chown *et al.,* 2012; Molina-Montenegro *et al.,* 2012).

Effects of anthropogenic activities to IAPs in Mt. Manunggal, Cebu Island, Philippines of all the anthropogenic activities found in Table 3, it was consumption (F-value=9.40; df= 1; p=0.005)that has the greatest impact on IAPs. Many residents plant IAPs on their garden and backyards which serve as their avenue for vegetable and fruit production. These practices help compensate their low salaries from their workplaces. Some residents use IAPs as feeds to livestock (F-value=5.81; df=1; p=0.022) to reduce cost of production and gain more profit (Huang 1994; Zhang, 2002) while others are sold in nearby markets (Chen and Xu, 2001; Liu *et al.,* 2003, 2005; Lopez-Pujol *et al.,* 2006; Xu *et al.,* 2006). As their purposes grew larger, more anthropogenic activities were also cited in the forest to compensate their increasing needs. Houses and garden were made in the patches of native trees, resulting to increased urbanization. Residents from nearby barangays and cities migrate to Mt. Manunggal in search for better way of living. For instance, urbanization indirectly assist introduction of the IAPs (i.e. human clothing, tires of

the vehicles, and shoes of the newly-arrived settlers) (Qiang *et al.,* 2000). Alongside with suitable environmental condition and allelopathic potentiality of IAPs in soil, it hastens germination and thus enhance invasion of IAPs (Callaway andAschehoug, 2000).

On the other hand, Table 3 showed that the identified purpose of most residents include Sold to People, Consumption, Feeds to Livestock, Human induced farming, Medicinal Purposes, Prevention of soil erosion, which affect the sudden invasion of IAPs in Mt. Manunggal.

Table 3. Effects of the resident's purpose of IAPs in the increase of its population on Mt. Manunggal, Cebu Island, Philippines.

Analysis of Variance (ANOVA)					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	35233235	5872206	5.95	0.000
Sold to people	1	41577524	157752	4.22	0.049
Consumption	1	92712569	271256	9.40	0.005
Feed to Livestock	1	57293275	729327	5.81	0.022
Human induced farming	1	47871734	787173	4.85	0.035
Medicinal Properties	1	10697451	069745	1.08	0.306
Prevent soil erosion	1	51365351	3653	0.52	0.476
Error	30	29591505	986383		
Total	36	64824740			
Model Summary					
S		R-sq		R-sq(adj)	
993.168		72.35%		70.22%	

Legend**:** p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05.

This explains a significant amount of the variance in the proliferation of IAPsin Mt. Manunggal ($F(6,30)=5.95$, $p= 0.000$, $R^2= 72.35\%$, $R^2_{adjusted} = 70.22\%$). Among all factors only the following purposes corresponds to the promotion of even more IAPs in Mt. Manunggal and resulted to significant amount of its increase in population: (1) Consumption, (2) Human Induced Farming, (3) Feeds to Livestock, and (4) being Sold to People.

Consumption ($F(1,30)=9.40$, $p= 0.005$) has the largest significant effect on the extent of its invasion followed by Feeds to Livestock ($F(1,30)=5.81$, $p= 0.022$), Human Induced Farming ($F(1,30)=4.85$, $p= 0.035$), and lastly being Sold to People ($F(1,30)=4.22$, $p= 0.049$). However, Medicinal Purposes ($F (1, 30)=1.08$, $p= 0.306$) and Prevention for Soil Erosion ($F(1,30) =0.52$, $p= 0.476$) revealed no significant effect on IAP population.

As presented in Table 4, Sold to People, Consumption, Feeds to Livestock, Human induced farming, Medicinal Purposes, Prevention of soil erosion are factors which increase the chances of proliferation of IAPs in Mt. Manunggal based on the significant amount of the variance ($F(6,30)=5.95$, $p= 0.000$, $R^2= 72.35\%$, $R^2_{adjusted} = 70.22\%$). Consumption has the largest significant effect on the extent of its invasion with an effect size of ($F(1,30)=9.40$, $p= 0.005$) while being Sold to People at ($F(1,30)=4.22$, $p= 0.049$) has the least significant effect on the invasion of IAPS in Mt. Manunggal. However, Medicinal Purposes and Prevention for Soil Erosion revealed no effect on the population of IAPs in the study sites ($F(1,30)=1.08$, $p= 0.306$, ($F(1,30) =0.52$, $p= 0.476$, respectively).

Of the 6 resident's purpose of IAPs in the increase of its population, Table 4 showed that Consumption,

Human Induced Farming, Feeds to Livestock, and being Sold to People that affects the extent of purpose of the residents in the area significantly predicted the promotion of even more IAPs in the study site (β_2=91.5, t=3.07, p= 0.005, β_4=63.3, t=2.20, p= 0.035, β_3=86.2, t=2.41, p= 0.022, and β_1=75.2, t=2.05, p= 0.049, respectively). That is, for every unit on the extent of Consumption, Human Induced Farming, Feeds to Livestock, and being Sold to People, a rise by 91.5 units, 63.3 units, 86.2 units, and 75 units, respectively, on the expected growth in the population of IAPs in the area. For Medicinal purposes and Prevention of Soil Erosion, both did not exhibit significance in the amass propagation of IAPs in Mt. Manunggal (β_5= -30.3, t= -1.04, p= 0.306, β_6= -14.6, t= -0.72, p= 0.476, respectively).

Table 4. Effects of the resident's purpose of IAPs in the increase of its population in Mt. Manunggal, Cebu Island, Philippines.

	Coefficients				
Term	Coef	SE Coef	T-value	P-value	VIF
Constant	-211	524	-0.40	0.690	
Sold to people	75.2	36.6	2.05	0.049	2.90
Consumption	91.5	29.8	3.07	0.005	2.35
Feed to Livestock	86.2	35.8	2.41	0.022	1.62
Human induced farming	63.3	28.7	2.20	0.035	1.21
Medicinal Properties	-30.3	29.1	-1.04	0.306	1.76
Prevent soil erosion	-14.6	20.2	-0.72	0.476	1.54
Regression Equation Model:					
No. of Species = -1503 + 32.8 Overgrazing + 47.2 Habitat Fragmentation + 12.0 Encroachment + 103.7 Natural Habitat loss + 55.0 Urbanization + 39.4 Economic purposes					

Legend**:** p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05.

Unceasing anthropogenic activities in Mt. Manunggal greatly affected as to how the people get their benefit from it. Consumption (F(1,30)=9.40, p= 0.005) of the IAPs was enough to address the immediate needs of the residents in the forest. Aside from consumption, human induced farming (F(1,30)=4.85, p= 0.035), being feed to livestock (F(1,30)=5.81, p= 0.022) and to sold as food are factors responsible for the different practices of human activities (F(1,30)=4.22, p= 0.049). The remunerations coming from the food sold at the market entices more residents to plant IAPs in the study site which provides their basic needs and satisfaction as they generate income out from these IAPs(Xu *et al.,* 2006; Malavasi *et al.,* 2014; Manier *et al.,* 2014; Molina-Montenegro *et al.,* 2015; Rojas-Sandoval and Acevedo-Rodríguez, 2014).These practices resulted to a positive feedback among the residents, causing them to unceasingly practice these anthropogenic activities (Xu *et al.,* 2006; Van Wilgen *et al.,* 2013).

Life forms of IAPs in Mt. Manunggal, Cebu Island, Philippines

The most abundant IAP life forms documented in the study site were primarily herbaceous and grasses in form. Table 5 revealed that the plant species affecting its spread explain a significant amount of the variance in the extent of its invasion in the study site (($F(4,32)=3.25$, $p= 0.024$, $R^2= 72.03\%$, $R^2_{adjusted} = 70.02\%$). Furthermore, the main effects of the following life forms tell us its direct effect to IAPs. It is observed that these life forms persist in most areas where habitat fragmentation is prevalent. As mentioned, anthropogenic activities provide an empty niche where alien plants are liberated and become invasive in a new environment (Van Wilgen *et al.,* 2013; Rojas-Sandoval and Acevedo-Rodríguez, 2014). Likewise, in livestock where cows and goats graze on the plains, this provides an opportunity for herbaceous plants as well as grasses to invade and

create a new founding population. Though considerable population of invasive alien trees and shrubs were identified in the study sites, grasses and the herbs still outnumber among others.

Species of grasses such *as Axonopus compressus, Pennisetum purpureum, Imperata cylindrica, Paspalum conjugatum, Cynodon dactylon, Dendrocalamus giganteus,* and *Bambusa vulgaris* represents 46% (n= 5569) of the total IAPs assessed in Mt. Manunggal while for the herbs, its representatives are *Mikania micrantha, Ageratum conyzoides, Colocasia esculenta, Hyptis capitata, Elephantopus mollis, Mimosa pudica, Erechtites valerianifolius,* and *Centrosema pubescens* constitutes the 46% (n=5569) of the total IAPs in the area.

Table 5. Invasive life forms of IAPs in Mt. Manunggal, Cebu Island, Philippines.

Analysis of Variance (ANOVA)					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	18741528	4685382	3.25	0.024
Tree	1	709124	709124	0.49	0.488
Shrub	1	1512589	1512589	1.05	0.313
Herb	1	6012829	6012829	4.18	0.049
Grass	1	8936325	8936325	6.21	0.018
Error	32	46083212	1440100		
Total	36	64824740			
Model Summary					
S	R-sq		R-sq(adj)		
1200.04	72.03%		70.02%		

Legend: p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05.

The remaining 8% (n=1031) is mixed with the population of both trees and shrubs. Apparently, majority of the grass species under family Poaceae tends to became more invasive when introduced in newly-pastured land of cattle and other live stocks (Williams and Baruch, 2000). This was also supported in the study of Rojas-Sandoval and Acevedo-Rodríguez (2014) and Higgins and Richardson (1999) in which the propagation of these grasses was caused by the formation of fragmented habitats made by humans in countries of China, Puerto Rico, and other European countries. After introduction, an interplay of different biotic and abiotic factors enhances the establishment and proliferation of IAPs (Richardson *et al.,* 2000; Catford *et al.,* 2009). Introduction-invasion continuum is an excellent concept to consider focusing on the proliferation and invasion of IAPs in Mt. Manunggal. Global trade, transportation and tourism and conversion of forests to campsites, enhanced with suitable environmental factors present in the forest, are the main factors to consider when it comes to the introduction, establishment and proliferation of IAPs in Mt. Manunggal, Cebu Island, Philippines.

Grasses were seen to be with largest impact in the population of IAPs with a size effect of (*F(1,32)=6.21, p= 0.018)* which is followed by Herbs, (*F(1,32)=4.18, p= 0.049)*. Conversely, for both Trees and Shrubs they did significantly showed high invasion rate in the study site (*F(1,32)=0.49 p= 0.488,* (*F(1,32)=1.05, p= 0.313,* respectively*)*. One of the morphological advantages of herbs is the presence of its stolon (Zhao *et al.*, 1989). Their small, winged-seeds also allow them to glide on air when dispersed intentionally or unintentionally (Rejmanek, 2000).Herbs which were seen in Mt. Manunggal were known to produce

lightweight propagules and seeds, with exceedingly adhesive covering and thus comes into contact with humans where these seeds and propagules can attach into the clothing of the human and finally reach a land where they can be dropped mechanically and germinate (Frenot *et al.,* 2005; Hughes *et al.,* 2010). Moreover, IAP runners rapidly spread out in the area once it is introduced and finally adapted with the environment.

Table 6. Invasive life forms of IAPs in Mt. Manunggal, Cebu Island, Philippines.

Coefficients					
Term	Coef	SE Coef	T-value	P-value	VIF
Constant	-495	723	-0.68	0.499	
Tree	42.8	61.0	0.70	0.488	3.83
Shrub	63.4	61.9	1.02	0.313	2.30
Herb	109.4	53.5	2.04	0.049	2.79
Grass	85.8	34.5	2.49	0.018	3.14
Regression Equation Model:					

No. of Species = -495 + 42.8 Tree + 63.4 Shrub + 109.4 Herb + 85.8 Grass

Legend**:** p-value<α=0.05 – Significant at α=0.05 p-value>α=0.05 – Not Significant at α=0.05.

An analysis, focused on invasive life forms, revealed that Herb and Grasses greatly dominate the IAPs in the study site (β_3*=109.4, t=2.04, p= 0.049,* β_4*=85.8, t=2.49, p= 0.018,* respectively) (Table 6) while Trees and Shrubs did not significantly show dominance in the area (β_1*=42.8, t=0.70, p= 0.488,* β_2*= 63.4, t=1.02, p= 0.313,* respectively). Trees and shrubs have lesser abundance compared with other life forms due to the invasion of IAPs in the area. In the study of Tilman (2004), novel species entering a community as rare propagules are unlikely to establish in the area unless it can survive and grow on the resources that are left by the native species. It is only when the propagule pressure of the invasive species was sufficiently high that the native competitors such as the endemic trees are unlikely to provide an absolute defense to the invasion (Frenot *et al.* 2005). For invasive tree and shrub species, their propagules are large and less in number compared with the two other life forms which produce light and numerous seed, making it hard for the trees and shrubs to increase its pressure to the native tree species (Chown *et al.,* 2012). However, anthropogenic activities are factors that deliberately add pressure to the propagules of invasive shrubs and seeds of invasive trees.

Conclusion

This study is the first systematic assessment of the impacts caused by IAPs in Mt. Manunggal, Cebu Island, Philippines and exemplifies harmonizing report to the invasion of IAPs in the Central Visayas region. Incessant human population leading to increasing needs and demands for resources impacts the invasion of IAPs. This scenario was observed in Mt. Manunggal, in which majority of the residents profusely utilize and patronize IAPs to earn a living. As agriculture blooms and urbanization grows rapidly, it promotes more prosperity in the locality. The purpose of the residents to utilize IAPs as a mean for their consumption, feed for their livestock, construction of their houses, medication, and for trade and business leads to more patronization of the IAPs. Eventually, the ignorance of the residents towards the negative consequence of IAPs invasion becomes a problem that may continue to persist if not addressed. Anthropogenic activities are key factors in the successful introduction, establishment and proliferation of IAPs. Some of these activities involve: (1) the conversion of forest into agricultural, industrial, and commercial lands, which creates empty niches and permits the IAPs in the forest; (2)

the prevalence of animal domestication, livestock and animal grazing in which these animals facilitate and hasten the introduction of propagules and seeds of IAPs into different areas, and lastly (3) some agricultural crops in the nearby farm could escape and can be introduced into the forest and successfully dominate the land and propagate. These IAPs in which the residents thought to be beneficial as their source of living and economic success, could become the reason of their greater loss in the future.

Acknowledgements

We would like to personally thank Dr. Mary Joyce L. Flores, Dr. Patricia Nazareno, Prof. Judith Silapan from the University of the Philippines Cebu for their helpful comments of the manuscript. We are also thankful to Prof. Mark Ian C. Andres who moderated and improved the manuscript significantly as well as Prof. Ricky Villeta from the University of San Jose Recoletos Cebufor giving his constructive advice on the statistical analyses of our research. This study was partially supported by the Department of Environment and Natural Resources (DENR) Region-VII and a Thesis grant from the Commission of Higher Education (CHEd) of the Philippines.

References

Almeida WR, Lopes AV, Tabarelli M, Leal IR. 2015. The alien flora of Brazilian Caatinga: deliberate introductions expand the contingent of potential invaders. Biological invasions **17(1),** 51-56. https://doi.org/10.1007/s10530-014-0738-6

AlsosIG, Ware C,

Elven R. 2015. Past Arctic aliens have passed away, current ones may stay. Biological invasions **17(11),** 3113-3123. https://doi.org/10.1007/s10530-015-0937-9

Bais HP, Broeckling CD, Vivanco JM. 2008. Root exudates modulate plant microbe interactions in the rhizosphere. Secondary metabolites in soil ecology. Springer, Berlin, Heidelberg, 241-252. https://doi.org/10.1007/978-3-540-74543-3_11

Bradley BA, Houghton RA, Mustard JF, Hamburg SP. 2006. Invasive grass reduces aboveground carbon stocks in shrublands of the Western US. Global Change Biology **12(10),** 1815-1822. https://doi.org/10.1111/j.1365-2486.2006. 01232.x

Cadotte MW, Murray BR, Lovett-Doust J. 2006. Ecological patterns and biological invasions: using regional species inventories in macroecology. Biological invasions **8(4),** 809-821. https://doi.org/10.1007/s10530-005-3839-4

Center for Invasive Plant Management. 2007. Invasive Plant and the 2007 Farm Bill Workshop Results. 333 Leon Johnson Hall Montana State University Bozeman **(406),** 994-5557.

Chamier J, Schachtschneider K, Le Maitre DC, Ashton PJ, Van Wilgen BW. 2012. Impacts of invasive alien plants on water quality, with particular emphasis on South Africa. Water SA **38(2)**, 345-356. https://doi.org/10.4314/wsa. v38i2.19

Charles J, Dukes JS. 2007. Impacts of invasive species on ecosystem services. Biological invasions 217-237. https://doi.org/10.1007/978-3-540-36920-2_13

Daehler CC, Carino DA. 1999. Threats of invasive plants to the conservation of biodiversity. Biodiversity and allelopathy: from organisms to ecosystems in the Pacific. Academia Sinica, Taipei, 21-27.

Denslow JS. 2003. Weeds in paradise: thoughts on the invasibility of tropical islands. Annals of the Missouri Botanical Garden, 119-127. https://doi.org/10.2307/3298531

Ecological Society of America. 2004. Invasive Species. [Internet] Available from: ERDB. 2009. www.esa.org/education/edupdfs/invasion.pdf

Frenot Y, Chown, SL, Whinam J, Selkirk PM, Convey P, Skotnicki M, Bergstrom DM. 2005. Biological invasions in the Antarctic: extent, impacts and implications. Biological reviews **80(1),** 45–72. https://doi.org/10.1017/S1464793104006542

Fried G, Laitung B, Pierre C, Chagué N, Panetta FD. 2014. Impact of invasive plants in Mediterranean habitats: disentangling the effects of characteristics of invaders and recipient communities. Biological invasions **16(8)**, 1639-1658. https://doi.org/10.1007/s10530-013-0597-6

Higgins SI, Richardson DM.1999. Predicting plant migration rates in a changing world: the role of long-distance dispersal. The American Naturalist **153(5),** 464-475. https://doi.org/10.1086/303193

Huang QQ, Qian C, Wang Y, Jia X, Dai XF, Zhang H, Wang GX. 2010. Determinants of the geographical extent of invasive plants in China: effects of biogeographical origin, life cycle and time since introduction. Biodiversity and conservation **19(5),** 1251-1259 https://doi.org/10.1007/s10531-009-9751-y

Huiskes, AH, Gremmen NJ, Bergstrom DM, Frenot Y, Hughes KA, Imura S, Ware C. 2014. Aliens in Antarctica: assessing transfer of plant propagules by human visitors to reduce invasion risk. Biological conservation **171**, 278-284. https://doi.org/10.1016/j.biocon.2014.01.038

International Union for Conservation of Nature. 2000. IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species. Aliens 11-15.

Joshi RC. 2006. Invasive alien species (IAS): concerns and status in the Philippines. In Proceedings of the International Workshop on the Development of Database (APASD) for Biological Invasion. FFTC, Taichung, Taiwan, China 1-23.

Keane RM, Crawley MJ. 2002. Exotic plant invasions and the enemy release hypothesis. Trends in Ecology & Evolution **17(4)**, 164-170. https://doi.org/10.1016/S0169-5347(02)02499-0

LiuJ, Ouyang Z, Pimm SL, Raven PH, Wang X, Miao H, Han N. 2003. Protecting China's biodiversity. Science **300(5623)**, 1240-1241. https://doi.org/10.1126/science.1078868

Lloret F, Médail F, Brundu G, Camarda I, Moragues EVA, Rita J, Hulme PE. 2005. Species attributes and invasion success by alien plants on Mediterranean islands. Journal of Ecology **93(3)**, 512-520. https://doi.org/10.1111/j.1365-2745.2005. 00979.x

Magee TK, Ringold PL, Bollman MA, Ernst TL. 2010. Index of alien impact: a method for evaluating potential ecological impact of alien plant species. Environmental management **45(4),** 759-778. https://doi.org/10.1007/s00267-010-9426-1

Malavasi M, Carboni M, Cutini M, Carranza ML, Acosta AT. 2014. Landscape fragmentation, land-use legacy and propagule pressure promote plant invasion on coastal dunes: a patch-based approach. Landscape ecology **29(9)**, 1541-1550. https://doi.org/10.1007/s10980-014-0074-3

Pyšek P, Richardson DM. 2006. The biogeography of naturalization in alien plants. Journal of Biogeography **33(12)**, 2040-2050. https://doi.org/10.1111/j.1365-2699.2006. 01578.x

Rasingam L, Parthasarathy N. 2009. Diversity of understory plants in undisturbed and disturbed tropical lowland forests of Little Andaman Island, India. Biodiversity and Conservation **18(4)**, 1045-1065. https://doi.org/10.1007/s10531-008-9496-z

Rejmanek M. 1996. Species richness and resistance to invasions. In Biodiversity and ecosystem processes in tropical forests. Springer, Berlin, Heidelberg. 153-172. https://doi.org/10.1007/978-3-642-79755-2_8

Rojas-Sandoval J, Acevedo-Rodríguez P. 2015. Naturalization and invasion of alien plants in Puerto Rico and the Virgin Islands. Biological invasions **17(1)**, 149-163. https://doi.org/10.1007/s10530-014-0712-3

Sala OE, Chapin FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Leemans R. 2000. Global biodiversity scenarios for the year 2100. Science **287(5459)**, 1770-1774. https://doi.org/10.1126/science.287.5459.1770

Sanz-Elorza M, Mateo RG, Bernardo FG. 2009. The historical role of agriculture and gardening in the introduction of alien plants in the western Mediterranean. Plant ecology **202(2)**, 247. https://doi.org/10.1007/s11258-008-9474-2

Sugiura S, Tsuru T, Yamaura Y, Hasegawa M, Makihara H, Makino SI. 2008. Differences in endemic insect assemblages among vegetation types on a small island of the oceanic Ogasawara Islands. Entomological Science **11(2),** 131-141. https://doi.org/10.1111/j.1479-8298.2008. 00263.x

Wikum DA, Shanholtzer GF 1978. Application of the Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. Environmental management **2(4)**, 323-329. https://doi.org/10.007/BF01866672

Yamashita N, Tanaka N, Hoshi Y, Kushima H, Kamo K. 2003. Seed and seedling demography of invasive and native trees of subtropical Pacific islands. Journal of Vegetation Science **14(1),** 15-24. https://doi.org/10.1111/j.1654-1103.2003.tb02123.x